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FILING DATE: ***February 27, 2004***
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022704

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PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c).

22264 U.S. PTO
60/547802
022704

INVENTOR(S)

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☐ *Additional inventors are being named on the ____ separately numbered sheets attached hereto*

TITLE OF THE INVENTION (280 characters max)

Toroidal Inductive Devices and Methods of Making the Same

Direct all correspondence to: **CORRESPONDENCE ADDRESS**

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ENCLOSED APPLICATION PARTS *(check all that apply)*

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☒ Drawing(s) *Number of Sheets* 15

☐ Application Data Sheet. See 37 CFR 1.76

☐ CD(s), Number ____

☒ Other (specify) early receipt card

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Respectfully submitted,

SIGNATURE [signature]

Date 2-27-04

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Docket Number: AP-9822

USE ONLY FOR FILING A PROVISIONAL APPLICATION FOR PATENT

Docket: T3571-908368

TOROIDAL INDUCTIVE DEVICES AND METHODS OF MAKING THE SAME

BACKGROUND OF THE INVENTION

[0001] This invention relates generally to the field of manufacturing inductive devices that have both an electrical portion and a magnetic portion. Specifically, it applies to inductive devices in which the electrical portion is formed in a generally toroidal shape, around which the magnetic portion is formed. This invention also relates to a process of installing the magnetic portion onto the generally toroidal shaped electrical core. When construction is complete, the unit is essentially annular with the electrical portion preferably encased and enveloped by the magnetic portion.

[0002] Lower frequency coil devices and transformers, those that have laminations or strips of predominately iron material for the core, have progressed slowly and fairly steadily over the last one hundred years. Some of the first transformers were of toroidal design, a design that has proven to be useful, but expensive, over the years and which currently occupies a very small yet important segment of the transformer industry. Those first toroidal designs were soon supplanted by laminated core technology such as E/I cores and associated types. The laminated E/I core designs predominate the transformer market today. A third type which later came into practice is the wound core type which currently also enjoys a segment of the market. Advances in transformers, beyond these three basic types, have been, in lower frequency applications, restricted to advances in materials. Specifically, changes have been made primarily in the material makeup of the

magnetic components. Moses (1990) published a chart, which tracks a gradual and roughly linear improvement in core materials over an 80-year span.

[0003] Whereas the advances in higher frequency applications have been at times dramatic and non-linear over the years, the lower frequency devices have not witnessed such a dramatic change. One relatively recent advance in the technology of lower frequency electromagnetic devices has been a core development utilizing thin amorphous ribbons for the core material. The amorphous nature of the ribbons offers attractive magnetic features and the thickness of the manufactured ribbon provides further electromagnetic advantages by dramatically reducing eddy current loss. Amorphous technology for the core material, further advances in the manufacture of generally toroidal types allowing the attractive features of a generally toroidal constructed device to be exploited, and wound core technology, contribute to the basis of this invention. The simple discovery of interleaving the E/I members of the laminated transformers has also provided a basis for this invention. Simply interleaving the E/I (for similar types such as a C/I, D/I and related variants) produces improved operation of the core due to a reduction in the effective gap distance and a reduction in flux leakage, as well as a reduction in the amount of flux that is forced out of the magnetic material at a nearly perpendicular angular relationship to the desired grain structure orientation of the material.

[0004] Toroidal inductive devices, in general, offer distinct advantages in many applications. The main drawback of conventional toroidal inductive devices is the cost of manufacturing them. Also, another drawback to conventional toroidal inductive devices is the lack of gap control that is possible. In some applications this leads to severe current in-rush problems that must be dealt with in a manner that typically requires additional expense, further exacerbating the cost drawbacks of

toroidal inductive devices. Investigation by the present inventor has revealed that although no gap control it is apparent, the flux, which is circular and closed by definition, must pass through an effective gap created by the core being spirally constructed and thus not integrally circular. See, for example, Figure 8. Because the gap is distributed along a length of core material, the virtual or cumulative gap is very small and thus rendered almost inconsequential to the operation of the device. Certainly, the gap is effectively so small that it is necessary in many cases to accommodate the current in-rush problem by adding protective circuitry to the basic device, for example, a current limiting resistor.

[0005] The dominance of the three conventional types of transformers within the industry dramatically points out the potential for improvements in the field. Whereas, E/I and wound core types enjoy cost advantages and generally toroidal types offer efficiency advantages, there may be a type that can allow the advantageous features of each to be incorporated into one device.

[0006] Previous attempts at such a device have included introduction of dual materials to the core in order to allow enhanced operation at both high and low current demand levels, for example with one material being a highly permeable material and another being a high magnetic saturation material. Such material change, however, has been an expensive proposition to bring to the practical nature of constructing inductive devices.

[0007] Wound core technology produces devices that are very competitive in one size range but not competitive at all sizes. Further, wound core manufacturing technology forces an additional on site annealing of the core material that becomes a major expense of the overall device construction.

[0008] The E/I family type of construction has proven to be quite economical yet still suffers from efficiency limitations as well as material limitations (it is not practical to include multiple types of materials in one core set). In E/I type construction, the laminates must be stamped out of magnetically active material and then handled in such a manner as to keep the laminates together prior to final assembly. Further, the EMI relationship both of receiving and of generating EMI has been a distinct consideration particularly with the E/I type of inductive devices.

SUMMARY OF THE INVENTION

[0009] The present invention provides toroidal inductive devices and methods of manufacturing such devices that overcomes the deficiencies of the prior art.

[0010] According to one aspect of the present invention, the magnetic portion is composed of a plurality of hollow magnetic components that are constructed to be sections of a toroid such that once they are formed they can be sliced on one side, say on the outer circumference of the annulus, and placed around the generally toroidal electrical component core. The magnetic components may fully or partially envelop the electrical component core. In an exemplary embodiment, the magnetic components are constructed of magnetic wire.

[0011] For simplicity of discussion, the toroid shall be referenced herein as having a circumference and diameter, which refer to the circumference and diameter as considered in a plane perpendicular to a central axis passing through the opening in the center of the toroid, i.e., the hole. The terms cross-sectional circumference and cross-sectional diameter shall refer to the cross-sectional circumference and diameter of one side of the toroid in a plane containing the central axis of the toroid.

[0012] The preferred construction process for the generally toroidal section shaped magnetic component is one of winding the magnetic wire onto jigs and/or forms that allow the wire to assume the desired geometric shape. For example, the jig may be in the shape of a toroid section with a cross-sectional diameter slightly larger than the cross-sectional diameter of the electrical component core. Wire is wound in bundles on the jig or form in the shape of the toroid section. The wire bundles may be secured by any of several means such as, for example, glue, tape, and other temporary mechanical means. Next, the bundle of magnetic wire that has been wound on the jig will be cut in order to accommodate the removal from the jig and the insertion and placement of the magnetic component onto the electrical component core. The toroidal sectional shaped magnetic components are placed on the toroidal form of the electrical component core. The installation of the magnetic components about the electrical component core is preferably done in one of three ways: the cut ends of the magnetic component may butt togcther, they may meet and overlap, or both butting and overlapping may be applied alternately. The modular magnetic components are placed about the electrical component core until the core is at least partially or fully enveloped by the magnetic components, which collectively constitute the magnetic portion of the device. The leads from the electrical core are allowed to pass through a gap between the modular magnetic components. Additionally, other elements of the inductive device may pass between the modular magnetic components such as cooling fins, cooling pipes, and channels placed between the modular magnetic components to allow heat dissipation more readily from the core and also allow heat dissipation from the inner recesses of the magnetic components as may be necessary.

[0013] In accordance with another aspect of the present invention, there is disclosed a method of forming the magnetic portion by winding magnetic wire

directly onto the electrical component core. This method of manufacturing toroidal inductive devices utilizes a generally "sewing action" to envelop the electrical core with magnetic wire which will form the magnetic portion of the inductive device. In an exemplary embodiment of this invention, one or more hooks engage a magnetic wire being fed from a spool to pull the magnetic wire partially around the electrical core. The manufacturing equipment will then move the electrical core to a second position allowing the hook to reach underneath the electrical core and engage the magnetic wire again thereby tightening the wire around the electrical core and pulling a second portion of magnetic wire partially around the core. This process is repeated as the electrical core toroid is rotated until the electrical core is essentially enveloped with magnetic wire that is knitted together, at least partially covering the electrical core, and completing a magnetic path that the flux can travel through as it emanates from the electrical component core. In an exemplary embodiment of this invention, multiple hooks and spools of magnetic wire may be utilized to envelop the electrical core with magnetic wire, and the magnetic wire may be placed in a parallel or a braided fashion. In an exemplary embodiment of the invention, the magnetic wire is placed in a parallel arrangement that provides the shortest path length for the magnetic flux to travel in and also reduces the abrasions and oppositions that could be set up in the braided arrangement.

BRIEF DESCRIPTIONS OF THE DRAWINGS

[0014] The foregoing and other aspects, features and advantages of the present invention will become apparent from the following description of the exemplary embodiments, with reference to the accompanying drawings, wherein:

[0015] Figure 1 is a plan view of an exemplary toroidal inductive device with a plurality of magnetic components placed on a toroidal electrical component core.

[0016] Figure 2 is a plan view of a partially constructed exemplary toroidal inductive device showing magnetic components placed on the electrical core and also showing a magnetic component prepared for placement about the electrical component core.

[0017] Figure 3A is a plan view of an exemplary magnetic component adjacent to a portion of the electrical component.

[0018] Figure 3B is a cross-sectional view of the exemplary magnetic component adjacent to the electrical component.

[0019] Figure 4 is a cross-sectional view of an exemplary toroidal inductive device constructed using exemplary magnetic components.

[0020] Figure 5 shows an exemplary magnetic component placed about the electrical core torus.

[0021] Figure 6 shows an exemplary matrix of wires placed onto the electrical core prior to the magnetic component being placed on the core.

[0022] Figure 7 shows various exemplary embodiments of the present invention.

[0023] Figure 8 shows the flux travel path in an exemplary generally toroidal inductive device.

[0024] Figure 9 represents an exemplary time sequence of steps showing the "sewing" method of placing the magnetic wire on the electrical core.

[0025] Figures 10A-10D show various exemplary views of the sewing method of manufacturing toroidal inductive devices.

[0026] Figure 11A shows a cross-sectional view of an exemplary electrical component with the magnetic component being wound around it using the "sewing" method.

[0027] Figure 11B shows an exemplary "sewing" method being performed on an electrical core where exemplary spools of magnetic wire and hooks used to perform the method are also shown.

[0028] Figure 12 is a photograph of several laboratory prototypes of exemplary toroidal inductive devices constructed in accordance with the invention.

[0029] Figure 13 is another such photograph of several laboratory prototypes of exemplary toroidal inductive devices in accordance with the invention.

[0030] Figure 14 is still another such photograph of several laboratory prototypes of exemplary toroidal inductive devices in accordance with the invention.

[0031] Figure 15 is a photograph of a clay laboratory model of an exemplary toroidal inductive device with models of the exemplary magnetic components installed.

[0032] Figure 16 is a photograph of a clay laboratory model of an exemplary toroidal inductive device with one model of an exemplary magnetic component installed and another model of a magnetic component prepared for installation.

[0033] Figures 17A-17E show various plan and projection views of exemplary toroidal section shaped magnetic components.

DETAILED DESCRIPTION

[0034] Figure 1 is a perspective view of a completed toroidal inductive device. The electrical core 11 of the device is generally toroidal in form. The function of the electrical core 11 is no different than that taught and understood in the

art. In an exemplary embodiment of the invention, the electrical core is generally toroidal in form because that geometric shape may allow the shortest electrical path combined with the shortest magnetic path. In practice, variations from the geometric form involve primarily the lengthening or shortening of one path at the expense of the other path. In the form shown, a plurality of magnetic components 12 are placed at adjacent or overlapping positions along the electrical core so as to partially or fully envelop the electrical core and enable the magnetic flux emanating from the electrical core to travel along the cross-sectional circumference of the electrical core. In an exemplary embodiment of the invention the magnetic component 12 is formed in a generally toroidal section having a larger cross-sectional circumference than the cross-sectional circumference of the electrical component torus and the component is placed about the electrical component core, which is then of a larger cross-sectional diameter, and may fully or partially envelop the electrical component core. The electrical component core may have leads 13 that egress from within the toroidal inductive device through the gap between two of the magnetic components. In an exemplary embodiment of the invention the electrical component core is wound of electrically conductive wire and the magnetic components are wound of magnetically active wire. In winding the magnetic components, the wire is formed around a jig that is shaped as a section of a toroid. In an exemplary embodiment of the invention, the wire is held together on the jig by means of an adhesive such as epoxy. In another exemplary embodiment of this invention the epoxy or other adhesive is impregnated with magnetic powder. However, it should be appreciated that any suitable method of securing the magnetic wire to the jig or form during manufacture can be used.

[0035] Figure 2 describes a toroidal inductive device in the process of being manufactured using modular magnetic components. The electrical core 11 has several

magnetic components 12 placed on it. An additional magnetic component 12a is shown in the process of being placed on the electrical core 11. In the form shown, the magnetic component 12a has been sliced for removal from the jig used to manufacture it. The slicing of magnetic component 12a creates two ends (15, 16), which, in the form shown, are abutted. In practice of the invention, magnetic component ends (15, 16) may be overlapped once the magnetic component 12a has been placed about the electrical core 11. In an exemplary embodiment of the invention the magnetic component 12 is thicker at the inner circumferential portion within the toroid interior opening and thinner at the outer circumferential portion of the toroid. The inner circumferential portion of the magnetic component 12 is shown in Figure 2 as number 14. The thicker inner circumferential portion 14 is created in winding the magnetic wire around the jig to form the magnetic component 12, wherein the wire gathers up in the inner circumference of the generally toroidal sectional jig. Electrical interface wires 13 egress from the inner portion of the toroidal inductive device via gaps between magnetic components 12. However, it should be appreciated that any suitable method that allows connection to the electrical component can be used.

[0036] Figure 3A shows a plan view of the magnetic component prior to placement about the electrical component core. Figure 3B shows a cross-sectional view of the magnetic component prepared for placement about the electrical component core. In particular, the magnetic component 12 is shown with cut ends 15 and 16 and thicker inner circumferential portion 14.

[0037] Figure 4 is a cross-sectional view of one side of a toroidal inductive device constructed using the method of the present invention, the cross section being taken in a plane containing the central axis of the toroid. Magnetic components (12a-

12c) are shown placed concentrically about the electrical component core 11. The magnetic components (12a-12c) are shown with ends 15 and 16 overlapping. In this exemplary embodiment of the invention, the magnetic components (12a-12c) have ends 15 and 16 aligned along the cross-sectional circumference of the core. In an alternative embodiment of the invention, the overlapping portion of ends (15, 16) will be placed in different positions circumferentially of the cross-section of the core so as to allow for more complete coverage of the electrical core by the magnetic components (12a-12c).

[0038] Figure 5 shows a diagrammatic plan view of a modular magnetic component placed about the electrical component core.

[0039] Figure 6 shows an exemplary embodiment of the invention wherein a matrix of wires is laid on to the electrical core prior to the magnetic components being placed on the electrical core 11. This matrix of wires placed onto the electrical core further enhances the flux connection (i.e., decreases effective gap).

[0040] Figure 7 shows various embodiments of the present invention. In particular, details of placing the modular magnetic components on the electrical core are shown.

[0041] Figure 9 shows a time sequence of a method of manufacturing a toroidal inductive device by means of "sewing" action wherein the magnetic wire is engaged by hook and pulled and formed about the electrical component core. Figure 9A shows the electrical component core with the magnetic wire first being applied and the hook for pulling the wire around the electrical core not yet engaging the magnetic wire this is the initial condition of the method of manufacturing. Figure 9B shows that the hook has engaged the magnetic wire from position 1 and pulled it to position 2 and in doing so has pulled a length of magnetic wire sufficient to partially

embrace the electrical component core. In Figure 9B the hook has remained stationary while the manufacturing machine has moved the electrical component core upwards. In doing so, this has caused the magnetic wire to partially embrace the electrical component core. In a further step not shown, the hook once again engages the magnetic wire coming from the feeder spool and pulls that portion of the magnetic wire underneath the electrical component core. In still a further step not shown, the electrical component core has been moved down thereby allowing the second portion of magnetic wire that was underneath the electrical core to partially embrace the bottom side of the electrical core cross-section and also placing the electrical core in position for the hook to be able to engage the magnetic wire and pull a portion of the magnetic wire across the top of the electrical core to partially embrace it. The steps described above are repeated as necessary while the electrical component core is rotated allowing for the partial or full coverage of the electrical component core with magnetic wirc. Figurcs 10A-10D show additional details conccrning the "sewing" method and various arrangements for placement of the wire and supply spools.

[0042] In Figure 11A, one side of an electrical component core 11 is shown in a cross-sectional view with two spools of magnetic wire. The magnetic wire is partially embracing the electrical component core and, as shown in Figure 10, the wires are looped within each other by the "sewing" action of the present invention.

[0043] In Figure 11B a cross-sectional view of the electrical component core is shown with the spools of magnetic wire feeding through needles that are used to wind the magnetic wire around the electrical component core in a "sewing" action. In an exemplary embodiment of the invention, the needle or hook that is operating on the inner portion of the electrical component core torus may be thin and long allowing for the placement of wire on the inside of the torus.

[0044] In an exemplary embodiment of the invention not shown in the figures, the "sewing" method of manufacturing a toroidal inductive device may further be enhanced with the addition of multiple hooks and supply reels of magnetic wire. This helps in the efficient manufacture of the toroidal inductive device. In an exemplary embodiment of the present invention using multiple wires, the wires may be placed in a parallel or braided fashion about the electrical component core. In an exemplary embodiment, the wire is a placed in a parallel fashion providing a reduced path length for the magnetic flux to travel and also reducing the aberrations in the magnetic flux path that may occur in a braided magnetic wire construction.

[0045] An advantage of constructing a toroidal inductive device using the modular magnetic components is that this method allows for a smaller inner diameter of and thus a more compact device. Another advantage of constructing toroidal inductive devices using such magnetic components is that this allows for the manufacturing of the modular sections of the magnetic components prior to the installation on the electrical component core. A further advantage of the present invention is to allow the manufacturing of the modular magnetic components using wire. Further, by allowing the magnetic components to be manufactured out of wire, efficient manufacturing may be achieved by using a machine in which a winding means is utilized to automate the process of manufacturing the magnetic components. Another advantage of the present invention is that the modular magnetic components may be made in a generally toroidal sectional shape and severed in various ways to allow the efficient and effective placement of the modular component easily onto the generally toroidal form of the electrical component core. Yet another advantage of the present invention is that the modular magnetic components may be clamped and secured in several different ways, resulting in a completed device that is compact and

efficient, yet inexpensive to manufacture. Still another advantage of the present invention is that the magnetic portion can be made of inexpensive wire. Further, if desired, wires of different materials can be used such that the effectiveness of the device is enhanced across the entire operating range from quiescent to maximum operation. Yet another advantage of the present invention is that the construction and arrangement of the magnetic portion about the electrical core provides for substantially homogenous, balanced and symmetrical paths for both the magnetic flux and the electrical current to pass through the magnetic portion and the electrical portion, respectively, thus greatly reducing or even eliminating hot-spot generation. Further still, this homogeneity serves to minimize flux path aberration, resulting in less harmonic distortion which further discourages the generation or amplification of undesirable frequency components within the generally toroidal shaped inductive device. The foregoing description of the exemplary embodiments of the invention has been presented for purposes of illustration. It is not intended to be exhaustive or to limit the invention to the precise forms disclosed.

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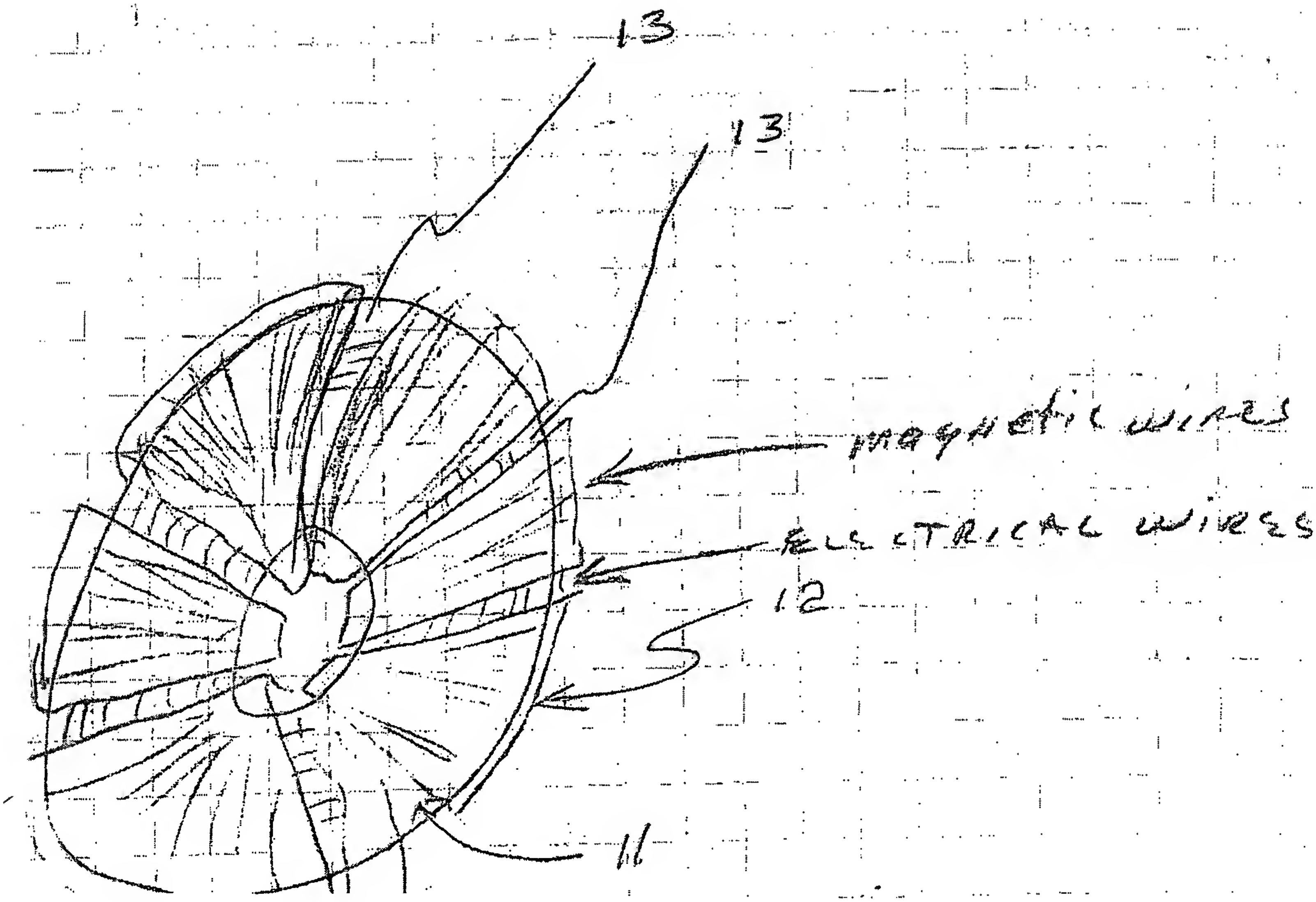


Fig. 1

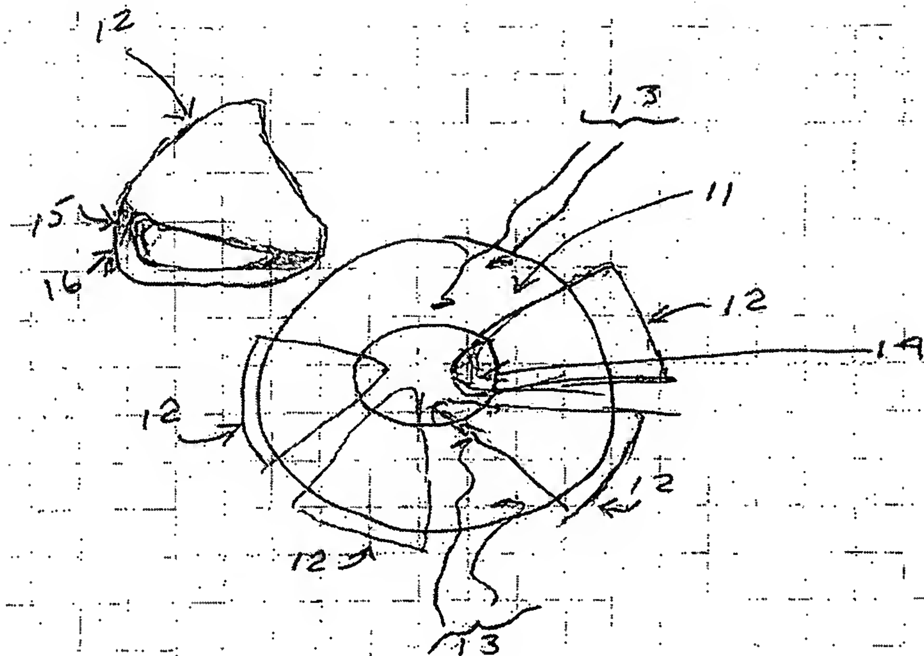


Fig. 2

NOTE 1 - WEDGES (MAGNETIC COMPONENTS)
ARE THEMSELVES MADE UP OF A
MATRIX OF WIRES - SUCH AS
WIRES IN COMBINATION WITH ADHESIVE
MAGNETIC OXIDE POWDER AMALGAM (ONE EXAMPLE

NOTE 2 - WEDGES ARE ECONOMICALLY / RAPIDLY CONSTRUCT
BY WINDING A CONTIGUOUS WEDGE OF
WIRES & ~~[illegible]~~ APPLYING AMALGAM IN PROCESS
- THEN WHEN WEDGE IS REMOVED FROM MACHINE
& AMALGAM HAS PARTIALLY SET UP, THE
WEDGE CAN BE CUT OPEN SO AS TO BE FITTED
ONTO THE ELECTRICAL CORE ANNULUS.

NOTE 3 - ANOTHER MANIFESTATION INCLUDES INSERTING
HEAT SINKS/PIPES INTO THE ELECTRICAL CORE, & PASSING
BETWEEN WEDGES SO AS TO DISSIPATE HEAT FROM THE
ELECTRICAL CORE. ONE MANIFESTATION IS CERAMIC
THERMALLY CONDUCTIVE ELECTRICALLY INSULATING Tubes

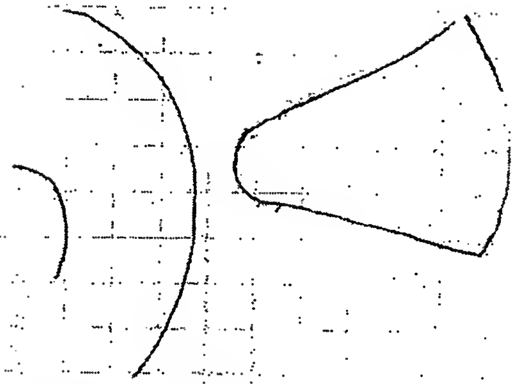


Fig. 3A

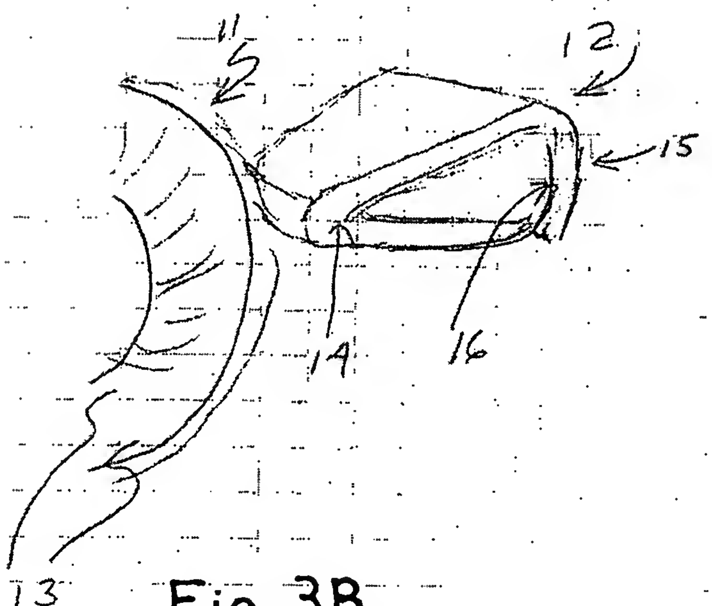


Fig. 3B

Note #4

I DONT KNOW HOW TO SHOW DIRECT CONNECTION TO PREVIOUS (TOROID) APPLICATION AND STILL BRING IN THE NOTION/CONCEPT/ /DISTINCTION OF "ELECTRICAL CORE" — BUT MAYBE SUGGESTING IN THE NEW APPLICATION THAT WHAT HAS BEEN CALLED "CORE" (THE MAGNETIC COMPONENT) MAY BE NEEDS RE LABELED TO BE NOW — MORE CORRECTLY TERMED — WITH THE "CORE" ACTUALLY BEING THE ELECTRICAL. !!

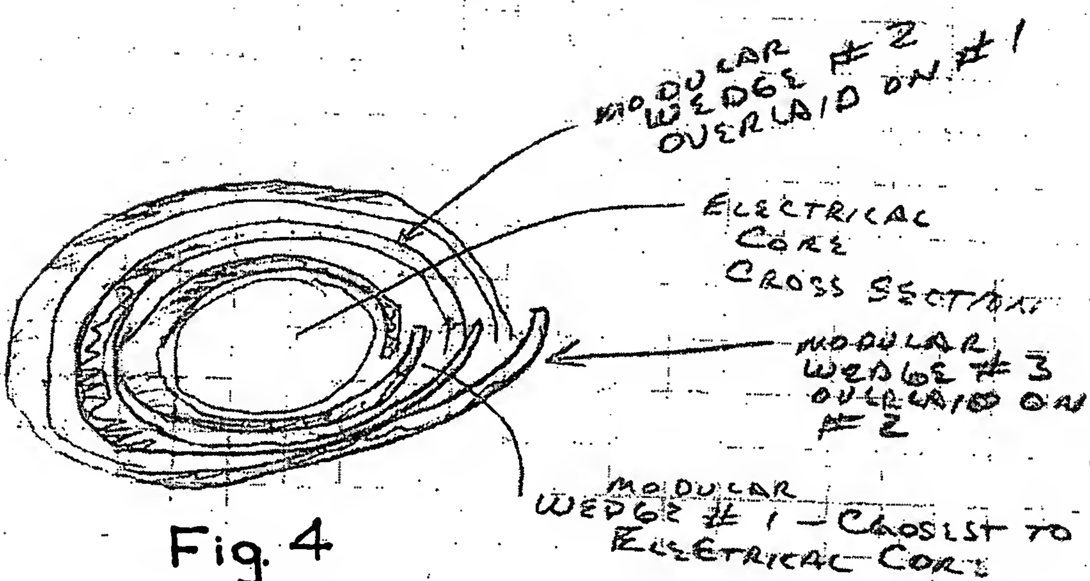


Fig. 4

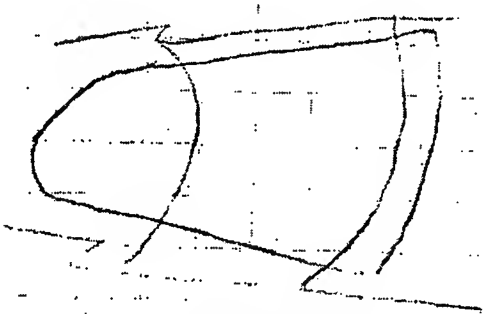


Fig. 5

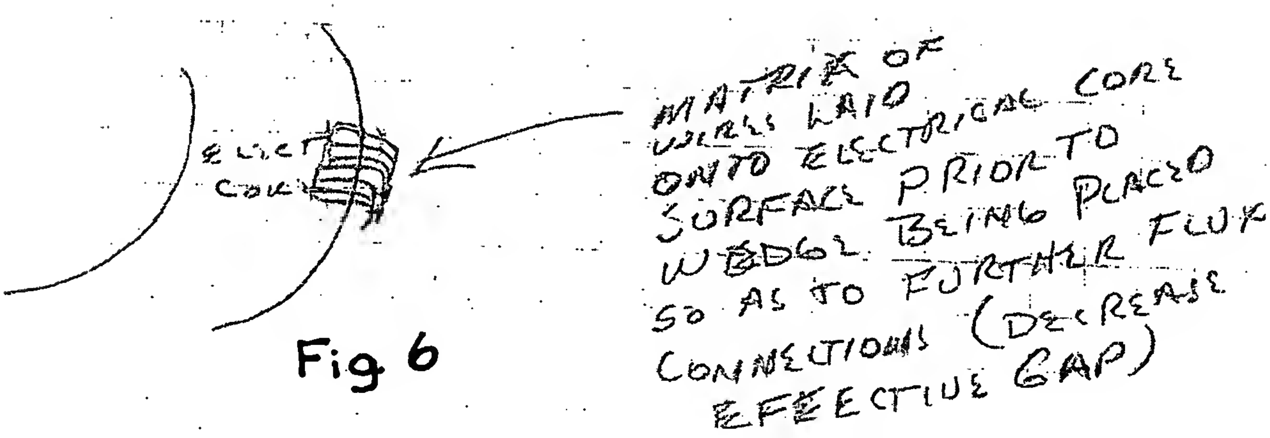
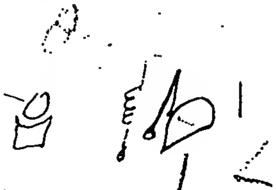


Fig. 6

copy of thing [illegible] To look [illegible]

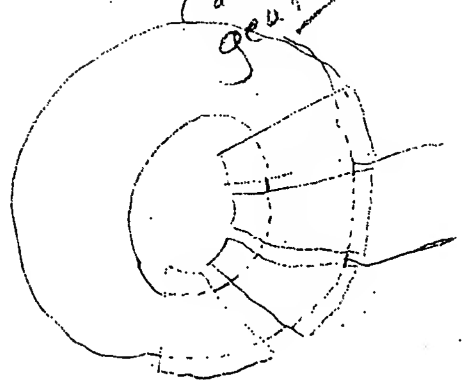
Fig. 7

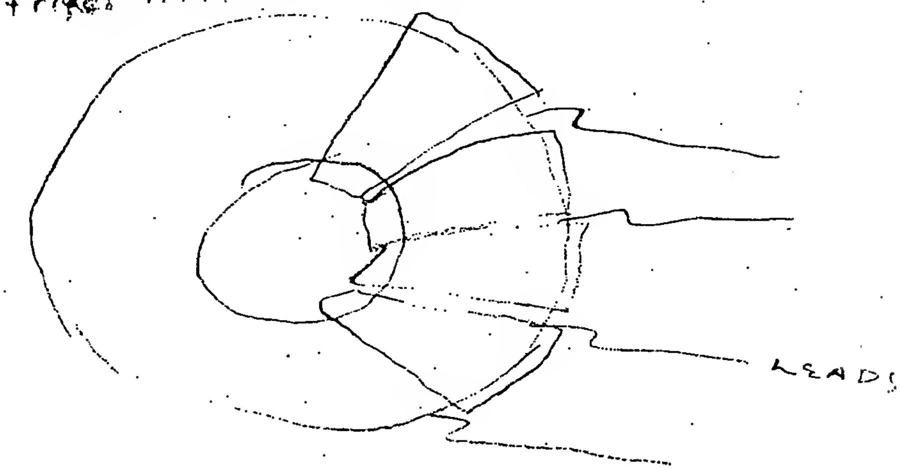
NUT



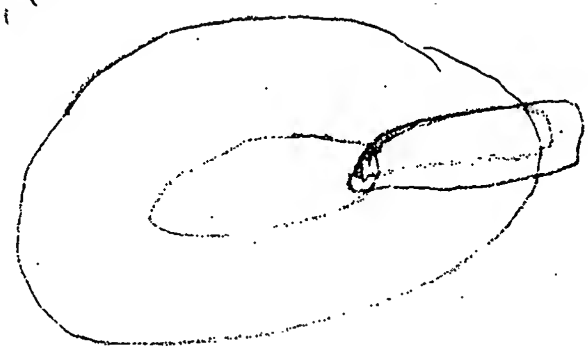
WHEN CRANK GOES AROUND
THE offset raises hammer trigger into latch
& pushes hammer trigger around offset
BRINGING CRANK ON [illegible] IT OUT
Strikes trigger

alternate
offset
cam be
geared





ALTERNATE build up pieces (segments)
shows [illegible] of Modular
now geometry is different



EXPLODED

ALTERNATE

ALT ALT
laying a
strip of
wire down
[illegible] put
ON

Coil winder
for
elect

heat handling

more Cylindrical
toroid
for Retrofits
other apps.

Coil winder
for moy

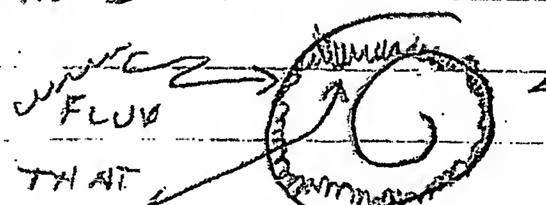
Coil winder
alternate

THE MAGNETIC MEDIA IN FORM OF WIRE OR WIRES DOES NOT NEED TO CIRCLE THE CENTRAL COMPONENT (CORE) WHICH IS NOW/HERE A SET OF WINDINGS OF ELECTRIC COMPONENTS (PRIMARY/SECONDARY).

RATHER, THE MAGNETIC MATERIAL CAN ENCIRCLE THE ELECTRICAL CORE IN RINGS, LOOPS, OR OTHER MANIFESTATIONS THAT PROVIDE ~~A~~ SUBSTANTIALLY COMPLETE MAGNETIC PATHS OF CIRCULAR FORM.

IN TEACHING THIS PRINCIPLE IT CAN BE NOTED THAT EVEN THOUGH IT IS SUGGESTED THAT TOROID (CONVENTIONAL TYPE) DO NOT HAVE GAPS IN THE MAGNETIC MEDIA THIS IS NOT EXACTLY SO. CONVENTIONAL TOROIDS HAVE NEAR ZERO EFFECTIVE GAP. THE MAGNETIC CORE IS A SPIRAL OR HELIX WHILE THE MAGNETIC FLUX IS A CIRCLE — THUS THE FLUX MUST TRAVERSE FROM ONE SPIRAL TO ANOTHER!

Fig. 8



FLUX

EXAGGERATED CORE WINDING OF A CONVENTIONAL TOROID

NOTE THAT FLUX MUST TRAVERSE GAP TO MAINTAIN CIRCULAR INTEGRITY/COMPLETION

FURTHER — "SEWING" ACTION

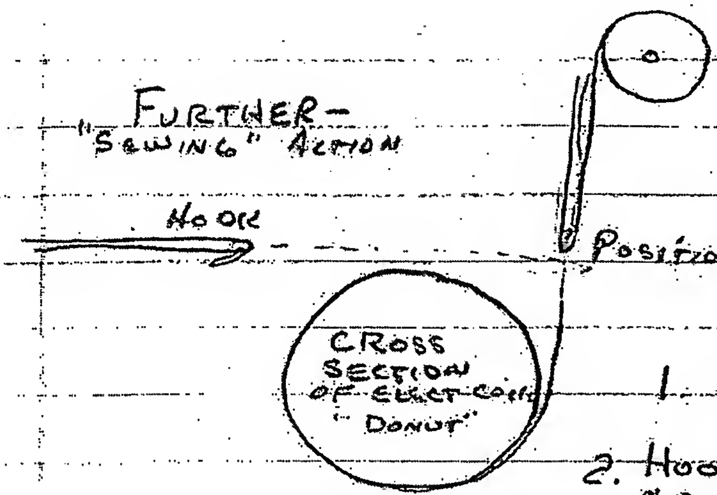


Fig. 9A

1. INITIAL CONDITION

2. HOOK GRABS WIRE & PULLS IT BACK TO POSITION 2

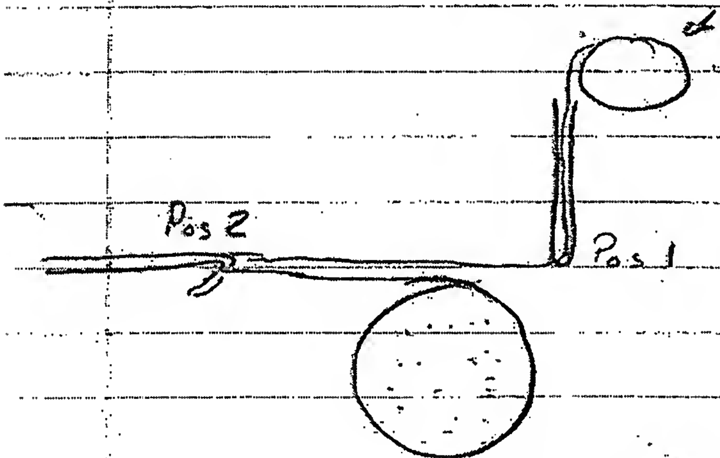
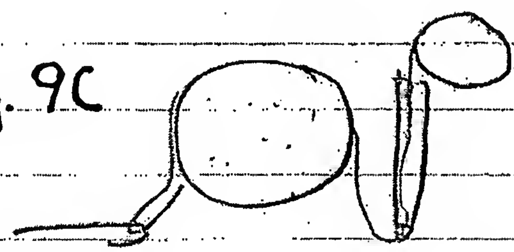


Fig. 9B

3

Fig. 9C



NEEDLE MOVES DOWN — OR — TORUS MOVES UP TO ALLOW HOOK TO MOVE BACK UNDER THE TORUS & ENGAGE AGAIN WITH VERTICALLY DESCRIBED NEEDLE.

Fig. 10A

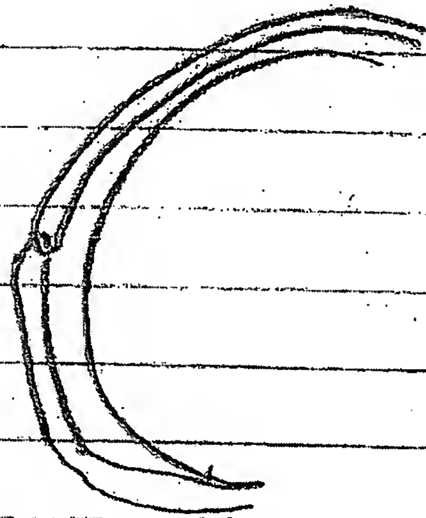
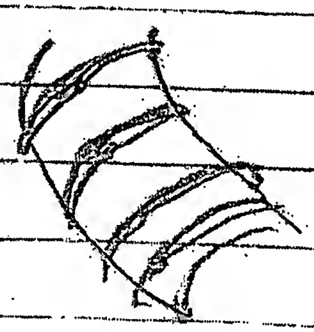


Fig. 10B



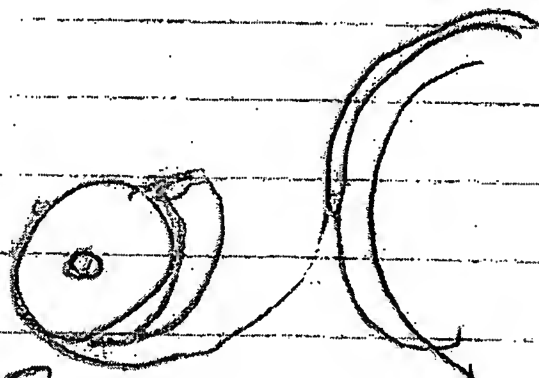
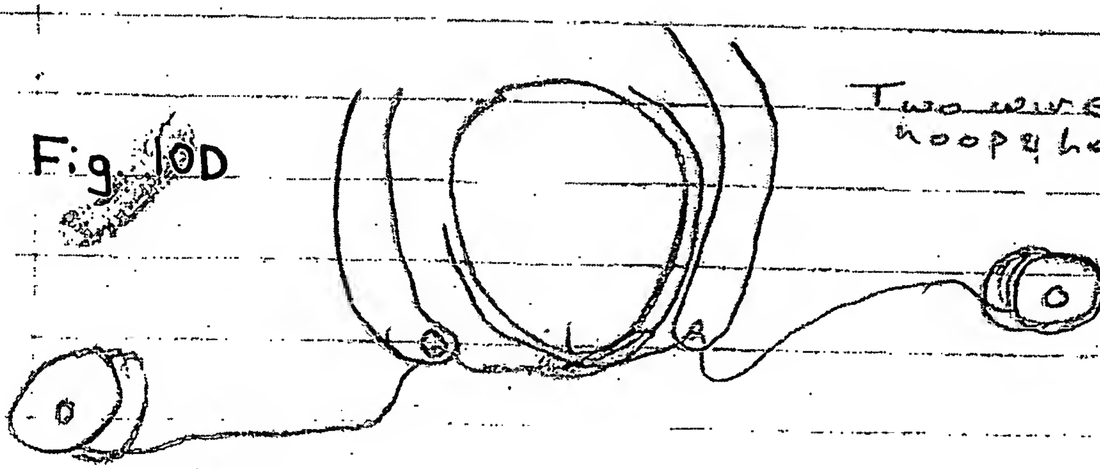


Fig. 10C

Supply Reel

Fig. 10D

Two wire "sewing" hoop & hoop arrangement



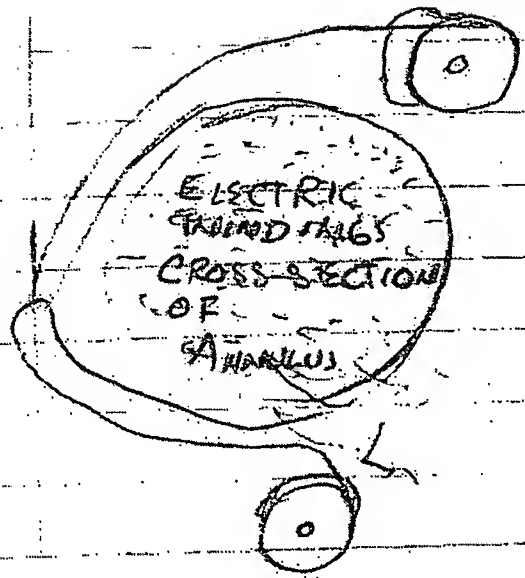
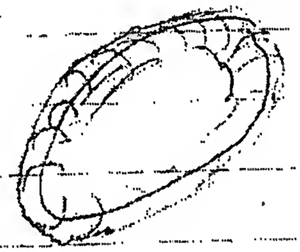


Fig. 11A



ANOTHER
MANIFESTATION

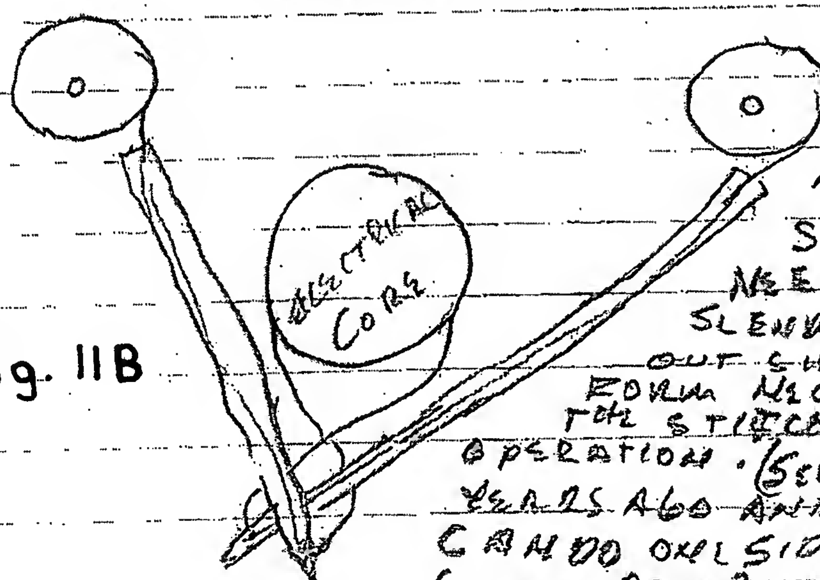


Fig. 11B

THIS CAN BE MANIFESTED JUST IN SAME WAY AS SEWING MACHINES SO THAT THE "INSIDE" NEEDLE IS LONG AND SLENDER WHILE THE OUTSIDE IS OF WHATEVER FORM NECESSARY TO FORM THE STITCHING (LOOP CONNECTING) OPERATION. (SEE Patents of 17+ YEARS AGO AND OLDER)

CAN DO OUTSIDE CONNECTIONS (MORE COMPLICATED) OR 2 SIDED (simpler) SO WIRE IS LIKE THIS:

BUT OF COURSE OVERLAPPED CONNECTED

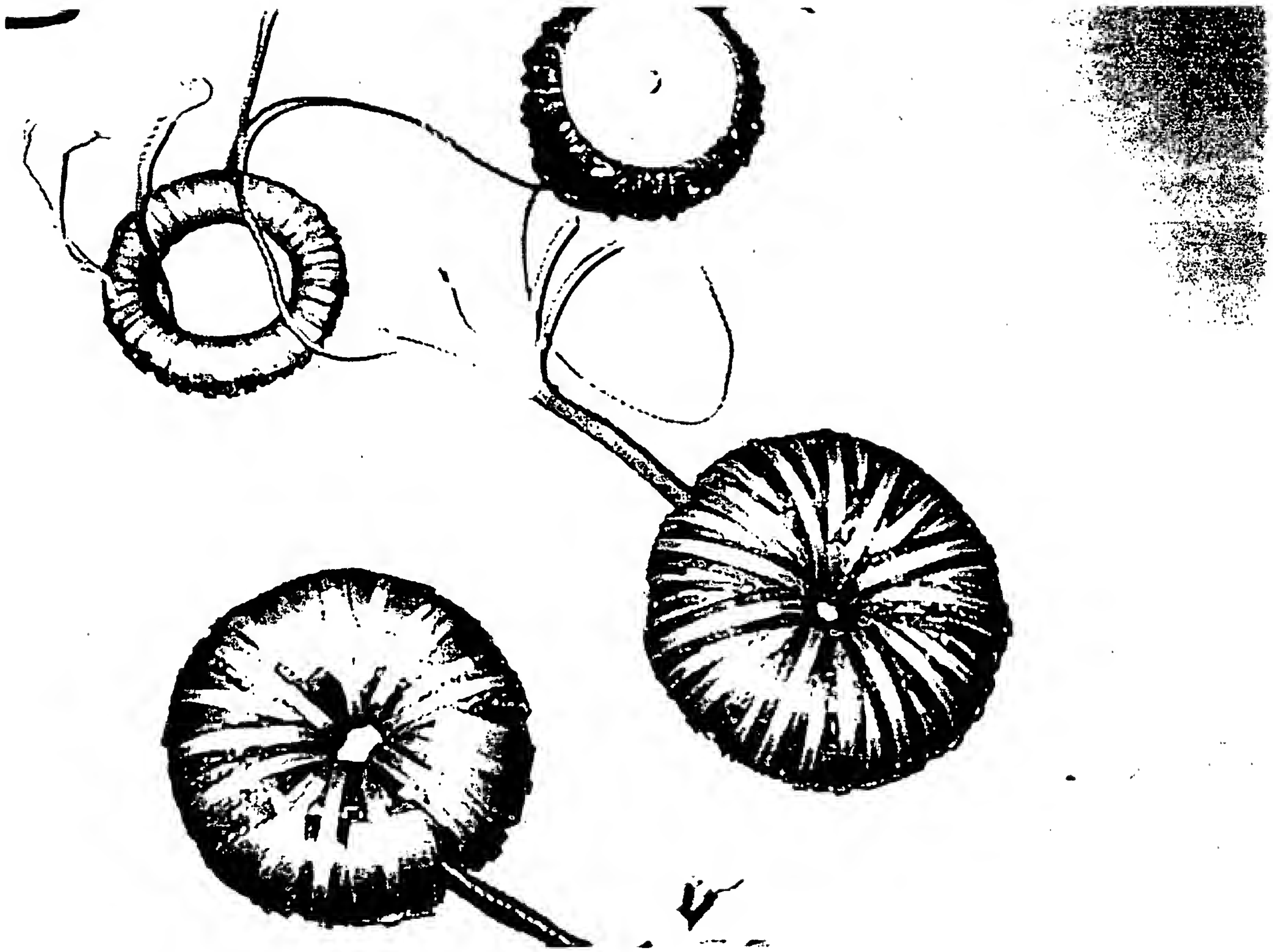


Fig. 12

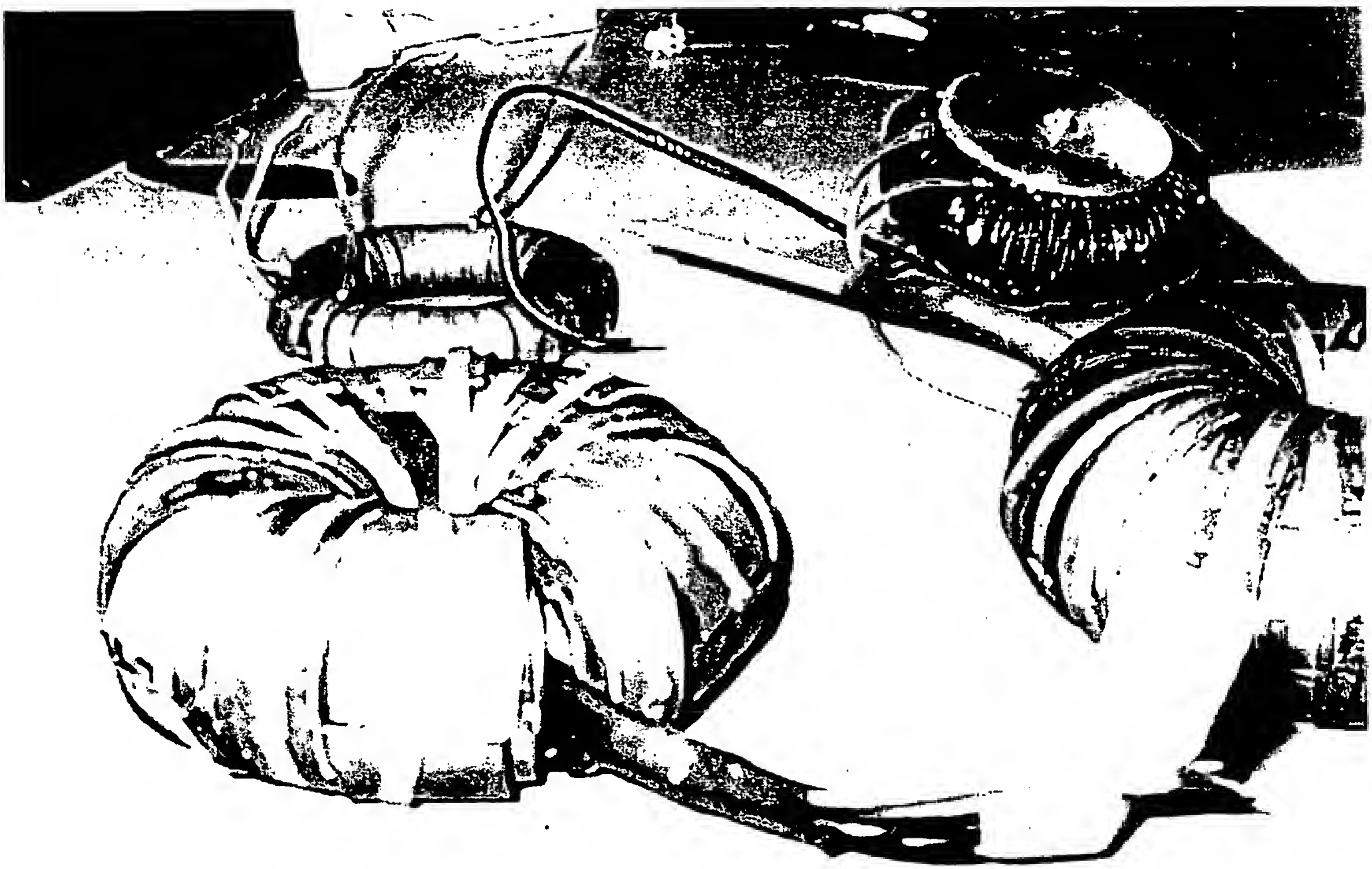


Fig. 13

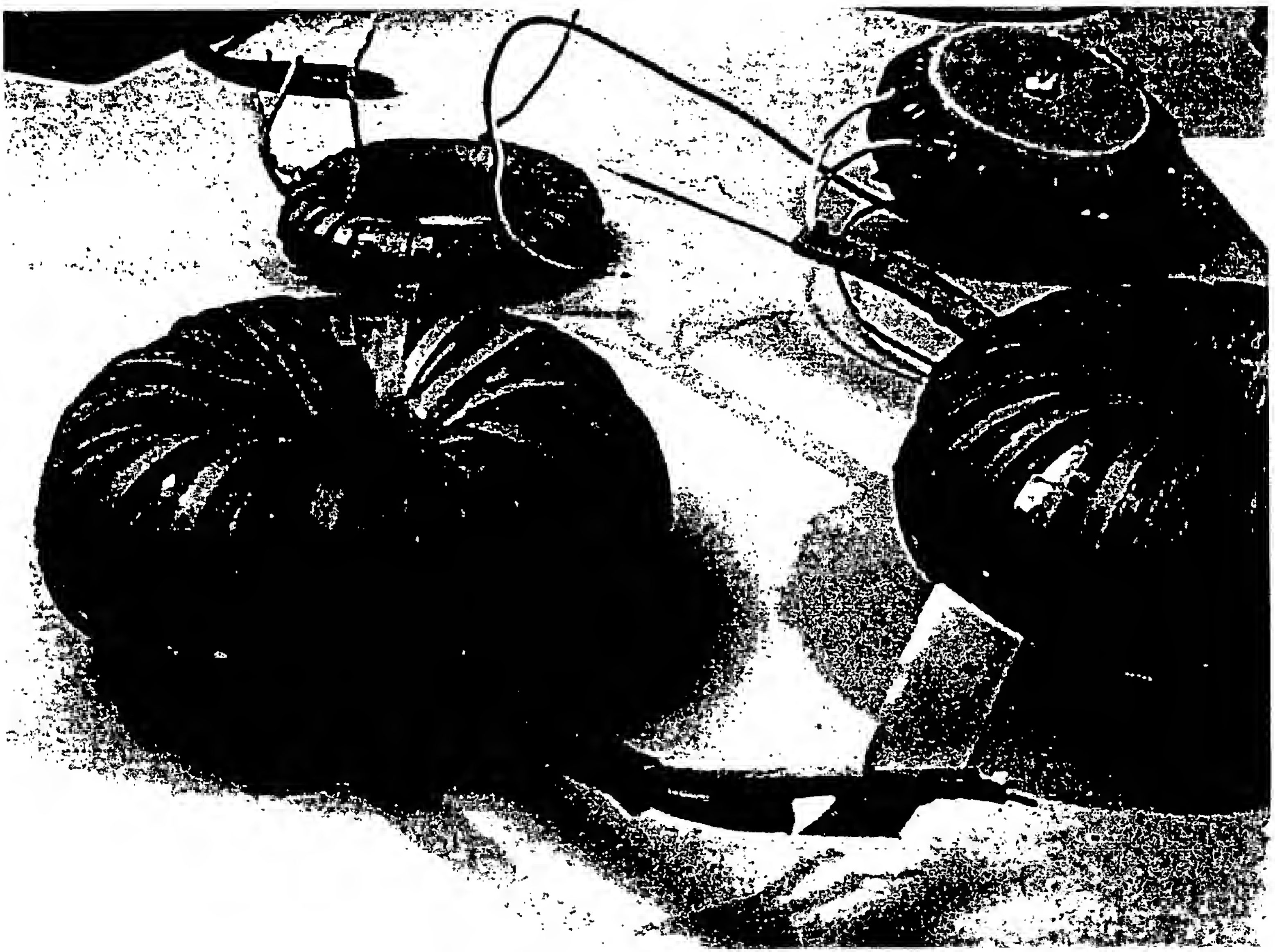


Fig. 14

Fig. 15

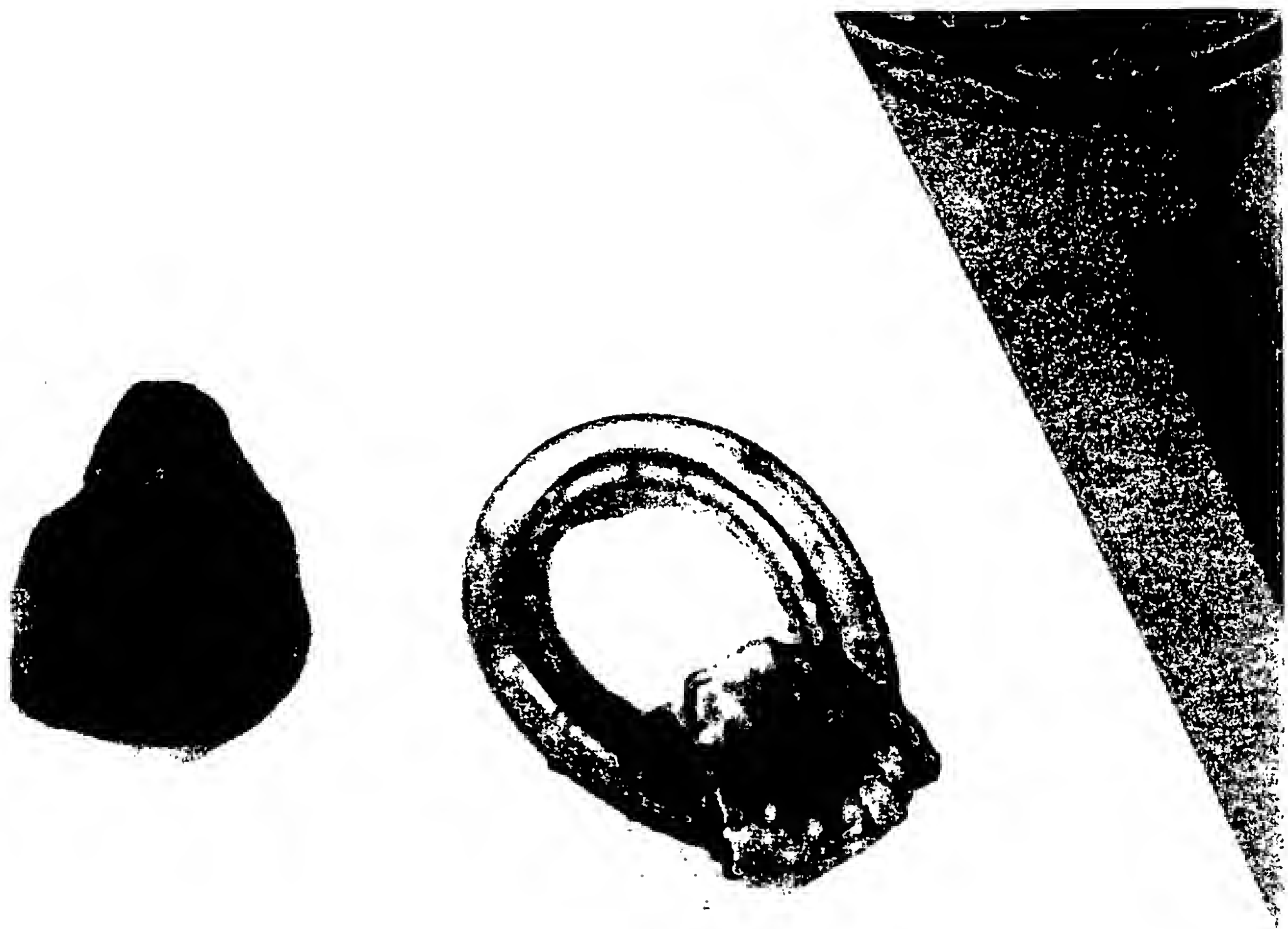


Fig. 16

HARRIE BUSWELL

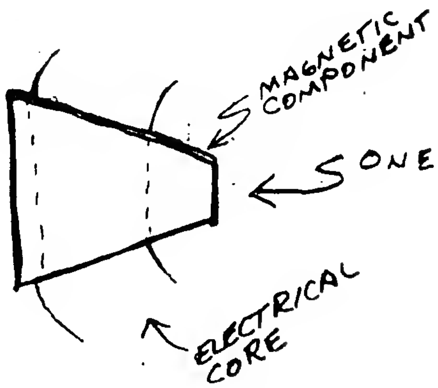


Fig. 17A

IF THESE WERE STRAIGHTENED OUT WOULD LOOK LIKE THIS:

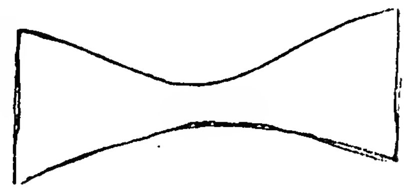


Fig. 17B

CUT ON WIDE

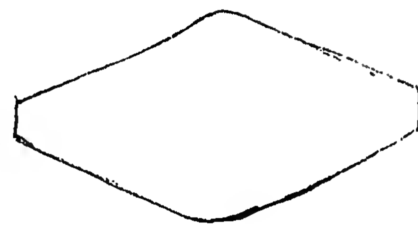


Fig. 17C

[illegible] OR NARROW)

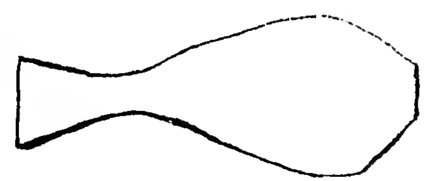


Fig. 17D

CUT ON [illegible]

ETC.

GAP HANDLING:

BUTT JOINTS

OVERLAP

& COMBINATIONS OF

PLUS CUTTING AT OBLIQUE ANGLES (BOTH WAYS THROUGH)


Fig. 17E

NOTE THAT IN SOME APPLICATIONS THAT EACH SECTOR CAN BE ACCOMPLISHED IN ONE PIECE AND DONE WITH A BUTT JOINT — OTHERS REQUIRE A BUILD-UP OF SECTOR PIECES (SORT OF LIKE AN ONION).